## REMARKS

As a preliminary matter, Applicants thank the Examiner for his careful examination of this application and for the search results contained in the Office Action. Claims 1-16 are pending. Claims 1, 4, 6, 7, 8, 9, 10, 12, 14, and 15 are independent claims. Claim 1-16 have been amended to better indicate antecedent basis throughout the claims. Claims 4-7, 9, 10, and 14 have been further amended to correct typographical errors or other oversights. Claims 8 and 12 have been amended to further articulate network elements. No claims have been added or canceled in this Amendment. No new matter has been added.

In the Office Action: (1) the drawings were objected to under 37 CFR 1.83(a) for not showing every feature of the invention specified in the claims; (2) claim 5 was objected to under 37 CFR 1.75(c) as being of improper dependent form; (3) claims 1-16 were rejected under 35 U.S.C. §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicants regard as the invention; (4) claims 1-3, 6, 7, and 9-11 were rejected under the doctrine of obviousness-type double patenting as being unpatentable over claim 6 of U.S. Patent No. 6,278,701 (hereinafter "the '701 patent"); and (5) claims 8, 12, and 13 were rejected as being incomplete for omitting essential elements. Applicants respectfully request that the Examiner withdraw these objections and rejections based on the amended drawings and claims and for the reasons discussed below.

### Objection to the Drawings

On page 2 of the Office Action, the Examiner objected to the drawings under 37 CFR 1.83(a) based on the assertion that all "means" in apparatus claims 4, 6, 7, 8, 12, and 13 are not shown in the drawings. Concurrent with this Amendment, Applicants have submitted replacement drawing sheets for consideration and approval by the Examiner. In the replacement drawings sheets, previous Figure 1 has been renumbered as Figure 2, and new Figure 1 has been added. Replacement Figure 1 is fully supported by the specification (e.g., see the first paragraph of the Detailed Description section) and illustrates an example of the "means" that are recited in the claims. In accordance with relevant 35 U.S.C. §112, sixth paragraph jurisprudence, however, the interpretation of the "means" as recited in claims 4, 6, 7, 8, 12, and 13 is in no way limited to "means" disclosed by Figure 1. Applicants respectfully request approval of the replacement drawing sheets, and it is respectfully submitted that the objection to the drawings should be withdrawn based on the replacement

drawings.

**Substitute Specification**

Concurrent with this Amendment, Applicants have amended the specification by submittal of a substitute specification. A clean copy and a marked-up copy of the substitute specification are attached to this Amendment. The substitute specification includes amendments made to bring the specification into line with the replacement drawing sheets. Specifically, the amended specification accurately references the replacement drawings and includes reference numbers that correlate with the reference numbers of replacement Figure 1. In additional, minor typographical errors have been corrected. The substitute specification contains no new matter.

**Objection to Claim 5**

On page 3-4 of the Office Action, the Examiner objected to claim 5 under 37 CFR 1.75(c) based on the assertion that claim 5 is directed to a method that fails to further limit the subject matter of claim 4, which is directed to an apparatus. Applicants have corrected this oversight by amending claim 5, which is now directed to a system. Therefore, Applicants respectfully request that the Examiner withdraw this objection.

**Rejection under 35 U.S.C. §112, Second Paragraph**

On pages 4-5 of the Office Action, the Examiner rejected claims 1-16 under 35 U.S.C. §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter that Applicants regard as the invention because the claims are asserted to lack antecedent basis in numerous places. Applicants thank the Examiner for the specific examples cited in the Office Action. By way of this Amendment, Applicants have amended claims 1-16 to better indicate antecedent basis. The amendments address the examples specified by the Examiner on pages 4-5 of the Office Action. Further, Applicants' representative has carefully reviewed and amended the claims to more distinctly indicate antecedent basis throughout the claims. The amendments to better indicate antecedent basis are merely clarifying and do not change the scope of the subject matter defined by the claims. Based on the amended claims, Applicants request that the Examiner withdraw this rejection of claims 1-16.

On page 5 of the Office Action, the Examiner suggested that all of the symbols in the scaling factor recited in claim 16 should be defined and their ranges specified. Applicants

thank the Examiner for this suggestion. However, Applicants respectfully submit that claim 16 as currently amended particularly points out and distinctly claims the subject matter that Applicants regard as the invention with at least a reasonable degree of clarity and particularity because one of ordinary skill in the art would readily understand what is claimed by claim 16 when read in light of the specification. MPEP 2173.02; *Orthokinetics, Inc. v. Safety Travel Chairs, Inc.*, 806 F.2d 1565, 1576, 1 USPQ2d 1081, 1088 (Fed. Cir. 1986). Because claim 16 is believed to satisfy the requirement for definiteness under 35 U.S.C. §112, second paragraph, Applicants have chosen not to amend claim 16 as suggested by the Examiner at this time. See MPEP 2173.02.

**Rejection of Claims 1-3, 6, 7, and 9-11 Under Obviousness-Type Double Patenting**

On pages 2-3 of the Office Action, the Examiner rejected claims 1-3, 6, 7, and 9-11 under the doctrine of obviousness-type double patenting as being unpatentable over claim 6 of U.S. Patent No. 6,278,701 (hereinafter "the '701 patent"). Concurrently with this Amendment, Applicants have filed a terminal disclaimer pursuant to 37 CFR 1.321(c) to overcome this rejection. Applicants' application and the '701 patent are commonly owned by Verizon Laboratories Inc. and University of Maryland. Accordingly, Applicants respectfully submit that the non-statutory double patenting rejection of claims 1-3, 6, 7, and 9-11 is obviated pursuant to 37 CFR 1.130(b).

Applicants note that the filing of the terminal disclaimer in no way admits that the claims of the application are obvious in view of the '701 patent. See *Quad Environmental Technologies Corp. v. Union Sanitary District*, 946 F.2d 870, 20 USPQ2d 1392 (Fed. Cir. 1991).

**Rejection of Claims 8, 12, and 13 for Omitting Essential Elements**

On pages 5-6 of the Office Action, the Examiner rejected claim 8, 12, and 13 as being incomplete for omitting essential elements. While the Examiner did not explicitly cite a statutory reference for this rejection, it appears (and Applicants assume) that the Examiner intended to cite 35 U.S.C. 112, first paragraph as the basis for the rejection. Applicants disagree with the Examiner's assertion that claims 8, 12, or 13 omit essential matter. An enablement rejection based on the grounds that a disclosed critical limitation is missing from a claim should be made only when the language of the specification makes it clear that the limitation is critical for the invention to function as intended (MPEP 2164.08(c)). Applicants respectfully submit that the specification does not limit the invention to a specific. allegedly

missing element for performing the limitations recited in claims 8, 12, or 13. To the contrary, the specification is written broadly as evidenced by the broad language of the Abstract, which tends to rebut the argument of criticality (MPEP 2164.08(c)). Accordingly, Applicants request that the Examiner explicitly identify any language in the specification upon which he relies to assert that the invention is limited to specific elements, allegedly missing from the claims, for carrying out the functions of interacting between users and a base station, determining minimum power and lowest ratio, and multiplying minimum power with the lowest ratio.

Even though Applicants believe that neither claim 8, 12, or 13 omits essential elements, Applicants have nonetheless amended claims 8 and 12 to improve the recitation of network elements, namely a contact between the users and the base station. Specifically, amended claim 8 includes the limitation of an active mobile user in contact with a base station via a link," and amended claim 12 includes the limitations of:

> a base station;
> at least one link; and
> at least one active network user in communication with said base station via said at least one link....

Based on the foregoing reasons and the amendments to claims 8 and 12, Applicants respectfully request that the Examiner withdraw this rejection of claims 8, 12, and 13 (claim 13 depends from claim 12), which are believed to be in condition for allowance.

## CONCLUSION

All objections and rejections have been addressed. In view of the above, the presently pending claims are believed to be in condition for allowance. Accordingly, the Examiner is respectfully requested to pass this application to issue. It is believed that any fees associated with the filing of this paper are identified in an accompanying transmittal. However, if any additional fees are required, they may be charged to Deposit Account 07-2347. To the extent necessary, a petition for extension of time under 37 C.F.R. 1.136(a) is hereby made, the fee for which should be charged against the aforementioned account.

Respectfully submitted,

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# POWER CONTROL FOR ACTIVE LINK QUALITY PROTECTION IN CDMA NETWORKS

Marked Up Version

## FIELD OF THE INVENTION

**[0001]** The present application claims priority based on the provisional application serial No. 60/169,849, filed on December 9, 1999, the entire contents of which are incorporated by reference. The present invention relates to protecting a Code Division Multiple Access (CDMA) data network from excessive interference in order to maintain the quality of service of the data network. A power control approach is disclosed to scale the power of all active links to achieve link protection and improved tolerance to interference.

## BACKGROUND OF THE INVENTION

**[0002]** Broadband CDMA systems, in the near future, will provide a wide range of multi-media services including voice, data, and video. With multi-media traffic, users present the network with a range of bandwidth and quality of services (QoS) requirements.

**[0003]** The performance of a CDMA system is interference limited. Interference can cause disruption in the service of dedicated bandwidth or circuit data users who have been admitted into the system and guaranteed frame error rate and throughput targets. In order to provide the quality of service ("QoS") guaranteed to data users, the interference in the system must be tightly controlled. Multi-access interference can be regulated by controlling the transmit powers of the users. Power control techniques that are designed only to combat fading, suffer the problem that an active new user can cause the signal to noise ratios of operational users to drop below their required threshold. Therefore, power control techniques must be designed to adjust the power when new users are admitted to the system, to maintain their guaranteed quality of service and for active link quality protection.

**[0004]** A detailed mathematical analysis of the affect of transmit power on the interference margin in a communications channel and how the link protection algorithm of the present invention was derived is presented in the following references, which are hereby incorporated by reference in their entirety:

**[0005]** D.V. Ayyagari and A. Ephremides in Power Control for Link Quality Protection in Cellular DS-CDMA Networks with Integrated (Packet and Circuit) Services. MOBICON 99 (Conference) September 15, 1999.

**[0006]** D.V. Ayyagari, Capacity and Admission Control in Multi-Media DS-CDMA Wireless Networks. Ph.D. Dissertation, University of Maryland, College Park, 1998.

## SUMMARY OF THE INVENTION

**[0007]** In Code Division Multiple Access (CDMA) systems the capacity is a function of the total interference on the system, which in turn depends on the received powers of all the users sharing the same frequency spectrum. A dynamic power control algorithm is used to control the received signal strength at the base station of a CDMA network. The transmit power levels of users are controlled by up/down commands issued on a forward link from the base station.

**[0008]** The base station dynamically computes the maximum received signal strength available from each user including the effect produced by path gain over the signal path to the base station. The base station then computes the minimum power required from each user that will meet the QoS and frame error rate requirements of each user. The maximum to minimum power ratio is determined for each user and the power ratio closest to unity, the weakest link, is determined. The weakest link power ratio is then used to scale upwardly the minimum power level of each user to provide the optimal operating power that will meet each user's "Quality of Service" (QoS) and frame error rate requirements with the lowest addition of interference to the network.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0009]** Figure 1 illustrates an application of an embodiment according to the present invention in a cellular communication environment.

**[0010]** Figure 2 ~~1~~ illustrates the steps in the algorithm of the present invention.

## DETAILED DESCRIPTION

**[0011]** For simplicity, the present invention will be described as used with a cellular communication system 1 having mobile user 2 in communications with a cell base station 3. The inventive system is implemented at the base station 3 but it is applicable to both the forward and reverse links 4-1, 4-2 (collectively referred to as the link 4). Forward = base to mobile, while reverse = mobile to base.

**[0012]** The link protection process begins at 5 of Figure 2~~-1~~, where each user 2 of the network is currently operating at individual power levels sufficient to meet its signal to noise ratio and quality of service requirements. The transmit power levels of the users 2 are controlled by the base station 3 via up/down commands 6 (shown in Figure 1) issued on the forward link 4-1. At this step, the mobile units 2 are operating at a power greater than the minimum required for their signal to noise ratios but less than or equal to their peak transmit power capability which is fixed by battery power. The weakest link needs a minimum transmittal power almost equal to the maximum transmittal power.

**[0013]** The base station 3 at step 7 dynamically calculates the path gain for each of the mobile units 2. This can be done by the base station 3 issuing a command 6 to the mobile unit 2 to transmit at a known power level and then measuring the received power. Received power = $T_\chi$ x path gain.

**[0014]** At step 9, the base station 3 computes the maximum received power possible from each mobile unit 2. At connection or communication set-up, the mobile unit 2 identifies the type of mobile unit 2 being used. The peak transmit power capability of each class of mobile unit 2 is known to the base station 3. From the path gain measurements, the base station 3 computes the maximum received power possible from each mobile user 2. The maximum received power equals peak transmit power times path gain.

**[0015]** At the next step 11, the base station 3 computes the minimum received signal power it needs to receive in order to maintain the quality of service and frame error rate requirements. The limitations of the base station 3 are known so the minimum received signal must be strong enough to overcome these limitations to meet the user's 2 service requirements. The minimum received power can be computed using the same equation used to solve for maximum received power but substituting minimum received power, which is known, and solving for minimum transmit power. Like the maximum power, it can also be determined by

sending command signals 6 from the base station 3 ordering the mobile unit 2 to reduce power until the signal to noise ratio is reached where the mobile unit 2 is just meeting its quality requirements. Testing in this manner, however, adds unnecessary noise to the data link.

**[0016]** A power ratio is then determined at 13 by dividing the maximum received power of each mobile unit 2 by the minimum received power each mobile unit 2 needs to meet its signal to noise ratio and quality requirements. The lowest power ratio determined for all of the mobile units 2, the power ratio of the weakest link, is selected for use as the scaling factor. The weakest link needs a minimum transmittal power almost equal to the maximum transmittal power.

**[0017]** The lowest power ratio or scaling factor is used at 15 to raise the minimum transmit power of all of the active mobile units 2. The base station 3 raises the powers of all active mobile units 2 by the up/down commands 6 on the forward link 4-1 by the scaling factor.

**[0018]** If the network is not heavily loaded, it is possible to raise the operating power of the active users 2 on the network. Therefore, it is necessary to determine an alternate scaling which does not raise the user powers beyond what is necessary. Let $\hat{B}$ be the required interference margin. Then the scaling factor $a$ that would provide the interference margin $\hat{B}$ can be determined as follows:

$$\hat{B} = \frac{\hat{a}s_i^{\min}}{T_i} - \sum_{j \neq i} \hat{a}s_j^{\min} - \eta$$

$$\hat{a} = \frac{\hat{B} + \eta}{\frac{s_i^{\min}}{T_i} - \sum_{j \neq i} s_j^{\min}}$$

**[0019]** where $i$ is the index of the code that has lowest minimum power $s_i^{\min}$. This results in the lowest power vector, which maintains link quality and provides the desired interference margin $\hat{B}$.

**[0020]** In accordance with the Telecommunications Industry Association's interim standard IS-95 the power control algorithm can issue update instructions at the rate of 800 updates/second to each active mobile user 2. Operating at approximately 850 MHz the path gain for a mobile unit 2 can change in a matter of inches. Interfering structures and foliage have a significant affect on the path gain.

**[0021]** Knowing the path gain as determined by the base station 3, it issues a command 6 for each active mobile unit 2 to transmit at a known power. (The base station 3, upon initial contact with the mobile user 2, ascertains the type of equipment the mobile unit 2 is using. The base station 3 has stored in memory the characteristics of the mobile unit 2 and what its power capability is for the unit 2.) The base station 3 then measures the power received. Knowing the path gain and the received power, base station 3 determines the maximum received power possible at the base station 3 for each user's mobile unit 2.

**[0022]** The link protection system will preferably be used continuously while the network is in operation to dynamically determine the operating power of the active mobile users 2 since the power ratio or scaling factor and the path gain vary continuously as a user 2 moves relative to the base station 3. The system is proven to yield significant improvements in capacity while maintaining the quality of service guarantees made by the network to high capacity users 2 currently active on the system.

**[0023]** While the invention has been disclosed in connection with the preferred embodiments shown and described in detail, various modifications and improvements thereon will become readily apparent to those skilled in the art. Accordingly, the spirit and scope of the present invention is to be limited only by the following claims.